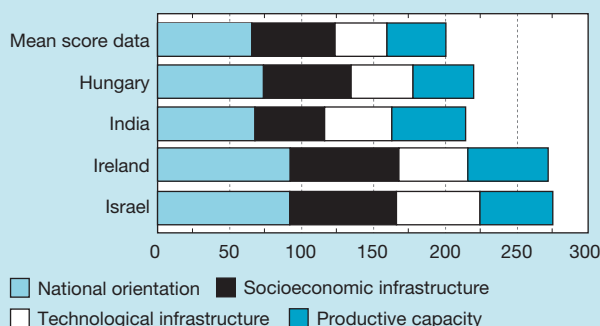


Figure 6-18.  
Composite scores for four new high-tech exporters



NOTE: Raw data were converted into scales of 0–100 for each indicator component.

See appendix table 6-8. *Science & Engineering Indicators – 2002*

times better than Hungary on the leading indicators, but its scores were not as balanced. Hungary's lowest ranking on any of the four indicators was 8th on the productive capacity indicator, while India's lowest ranking was 11th on the socioeconomic indicator. India's large population helped to elevate its scores on several indicators.

These indicators provide a systematic approach for comparing future technological capability on an even wider set of nations than might be available using other indicators. The results highlight a broadening of the group of nations that may compete in high-technology markets in the future while also reflecting the large differences between several of the emerging and transitioning economies and those considered newly industrialized.

## International Trends in Industrial R&D

In high-wage countries such as the United States, industries stay competitive in a global marketplace through innovation (Council on Competitiveness 2001). Innovation leads to better production processes and higher quality products, thereby providing the competitive advantage high-wage countries need when competing against low-wage nations.

R&D activities serve as incubators for the new ideas that can lead to new products, processes, and industries. Although they are not the only source of new innovations, R&D activities conducted in industry-run laboratories and facilities are the source of many important new ideas that have shaped modern technology.<sup>17</sup>

U.S. industries that traditionally conduct large amounts of R&D have met with greater success in foreign markets than those that are less R&D intensive, and they have been more supportive of higher wages for their employees. (See "U.S. Technology in the Marketplace" section for a presentation of

recent trends in U.S. competitiveness in foreign and domestic product markets.) Moreover, trends in industrial R&D performance are leading indicators of future technological performance. The following section examines these R&D trends, focusing particularly on growth in industrial R&D activity in the top R&D-performing industries in the United States, Japan, and the EU.<sup>18</sup>

## R&D Performance by Industry

The United States, the EU, and Japan represent the three largest economies in the industrialized world and are competitors in the international marketplace. An analysis of R&D data can explain past successes in certain product markets, provide insights into future product development, and highlight shifts in national technology priorities.<sup>19</sup>

### United States

R&D performance by the U.S. service-sector industries underwent explosive growth between 1987 and 1991, driven primarily by computer software firms and firms performing R&D on a contract basis. In 1987, service-sector industries performed less than 9 percent of all R&D performed by industry in the United States. During the next several years, R&D performed in the service sector raced ahead of that performed by U.S. manufacturing industries, and by 1989, the service sector performed nearly 19 percent of total U.S. industrial R&D, more than double the share held just two years earlier. By 1991, service-sector R&D had grown to represent nearly one-fourth of all U.S. industrial R&D. Since then, R&D performance in U.S. manufacturing industries increased and began growing faster than in the burgeoning service sector. Manufacturers' share inched back up to 80 percent of total U.S. industry R&D by 1996, the latest year for which internationally comparable data are available. Industries making computer hardware, electronics equipment, and motor vehicles led this resurgence in manufacturing-sector R&D. (See figure 6-19 and appendix table 6-9.)

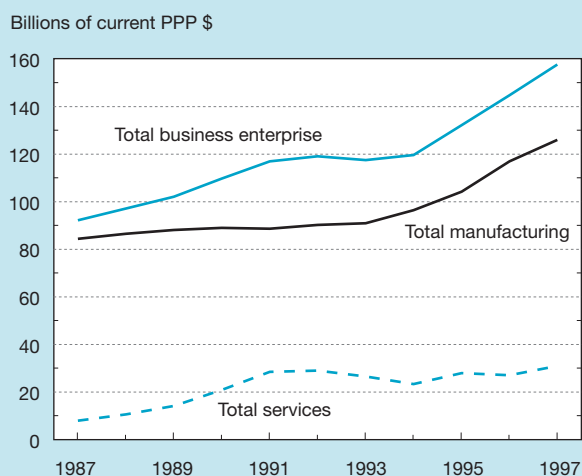
From 1987 to 1992, the U.S. aerospace industry performed the largest amount of R&D, accounting for 14 to 26 percent of total R&D performed by industry. The industry manufacturing electronics equipment (including communications equipment) and the U.S. chemical industry (including pharmaceuticals) followed, each accounting for between 9 and 16 percent of total U.S. R&D. During the mid-1990s, however, the nation's R&D emphasis shifted; the aerospace industry's share declined, and the share for the industry manufacturing communications equipment increased. In 1996 and 1997, the industry manufacturing communications and other electronics equipment was the top R&D performer in the United States.

<sup>17</sup>For a discussion of trends in foreign direct investment in R&D facilities, see chapter 4.

<sup>18</sup>This section uses data from OECD's Analytical Business Enterprise R&D database (OECD 2000) to examine trends in national industrial R&D performance. This database tracks all R&D expenditures (both defense- and non-defense-related) carried out in the industrial sector, regardless of funding source. For an examination of U.S. industrial R&D by funding source, see chapter 4.

<sup>19</sup>Industry-level data are occasionally estimated here to provide a complete time series for the 1987–97 period.

Figure 6-19.  
U.S. industrial R&D performance: 1987–97



Top industrial R&D performers and share of total industrial R&D (percents)

1987		1992		1997	
Aerospace	27.1	Services	24.3	Services	19.7
Electronic equipment	15.9	Aerospace	14.8	Electronic equipment	13.0
Chemicals	10.5	Chemicals	12.9	Chemicals	12.1
Computers and office machines	10.1	Computers and office machines	9.6	Computers and office machines	11.6
Motor vehicles	10.1	Electronic equipment	8.9	Aerospace	10.7

PPP = purchasing power parity

See appendix table 6-9. *Science & Engineering Indicators – 2002*

## Japan

Unlike the United States, Japan has yet to see a dramatic growth in service-sector R&D. Although R&D in Japan's service-sector industries reached 4.2 percent of the total R&D performed by Japanese industry in 1996 and 4.5 percent in 1997, Japan's industrial R&D performance continues to be dominated by its manufacturing sector. From 1987 to 1995, Japan's manufacturing sector consistently accounted for nearly 98 percent of all R&D performed by Japanese industry. (See figure 6-20 and appendix table 6-10.)<sup>20</sup>

The top industrial R&D performers in Japan during the 1987–97 period reflect that country's long-standing emphases on electronics technology (including consumer electronics and audiovisual equipment), motor vehicles, and electrical machinery. Japan's electronics equipment industry was the leading performer of R&D throughout the period, accounting for nearly 17 percent of all Japanese industrial R&D in 1997. Japan's motor vehicle industry was the second-best R&D performer and has retained that position nearly every year through 1997. Producers of electrical machinery became Japan's second-best R&D-performing industry in 1994 be-

<sup>20</sup>Revised Japanese R&D data for 1997 are reported in the "International Comparisons" section of chapter 4. Those data include a correction not incorporated here because of the inability to carry the correction backward and revise the complete historical series. The revision does not materially alter the observations discussed in this section.

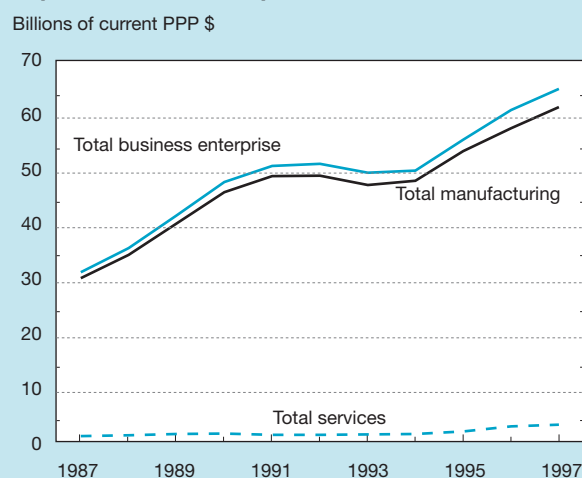
fore falling back to the third position, which they have held for several years. In 1997, manufacturers of electrical machinery accounted for nearly 11 percent of all industrial R&D performed in Japan. By comparison, since the early 1970s, U.S. producers of electrical machinery have steadily dropped in rank among the country's top R&D performers.

## European Union

As in Japan and the United States, manufacturing industries perform the bulk of industrial R&D in the 15-nation EU. The EU's industrial R&D appears to be somewhat less concentrated than that in the United States but more so than that in Japan. Manufacturers of electronics equipment, motor vehicles, and industrial chemicals have consistently been among the top five performers of industrial R&D in the EU. (See figure 6-21 and appendix table 6-11.) In 1997, Germany led the EU in the performance of motor vehicle and industrial chemical R&D, France led in industrial R&D performed by electronics equipment manufacturers, and the United Kingdom led in pharmaceuticals R&D.

R&D within the EU's service sector has doubled since the mid-1980s, accounting for about 11 percent of total industrial R&D by 1997. Large increases in service-sector R&D are apparent in many EU countries, but especially in the United Kingdom (19.6 percent of its industrial R&D in 1997), Italy (15.3 percent), and France (10.0 percent).

Figure 6-20.  
Japan industrial R&D performance: 1987–97



Top industrial R&D performers and share of total industrial R&D (percents)

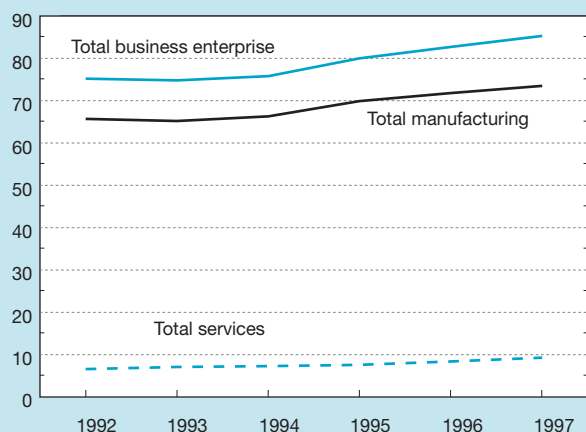
1987		1992		1997	
Electronic equipment	18.0	Chemicals	16.8	Electronic equipment	16.6
Chemicals	116.9	Electronic equipment	16.7	Chemicals	15.1
Motor vehicles	12.2	Motor vehicles	13.3	Motor vehicles	13.2
Electrical machines	10.3	Office machines	8.6	Electrical machines	10.7
Machinery, N.E.C.	8.2	Machinery, N.E.C.	8.3	Office machines	9.9

PPP = purchasing power parity; N.E.C. = not elsewhere classified

See appendix table 6-10. *Science & Engineering Indicators – 2002*

Figure 6-21.  
European Union industrial R&D performance:  
1992–97

Billions of current PPP \$



Top industrial R&D performers and share of total industrial R&D (percents)

	1987	1992	1997
Data not available		Chemicals 19.5	Chemicals 20.7
		Motor vehicles 13.7	Motor vehicles 14.7
		Electronic equipment 10.7	Electronic equipment 12.8
		Aerospace and other transport equipment 10.7	Total services 10.9
		Machinery, N.E.C. 8.8	Aerospace and other transport equipment 8.9

PPP = purchasing power parity; N.E.C. = not elsewhere classified

See appendix table 6-11. *Science & Engineering Indicators – 2002*

## Patented Inventions

Inventions have important economic benefits to a nation because they often result in new or improved products, more efficient manufacturing processes, or even new industries. To foster inventiveness, nations assign property rights to inventors in the form of patents, which allow the inventor to exclude others from making, using, or selling the invention. Inventors can obtain patents from government-authorized agencies for inventions judged to be new, useful, and not obvious.

Although the Patent and Trademark Office (PTO) grants several types of patents, this discussion is limited to utility patents only, which are commonly known as patents for inventions. Patenting indicators have several well-known drawbacks, including the following:

- ◆ **Incompleteness.** Many inventions are not patented at all, in part because laws in some countries already provide for the protection of industrial trade secrets.
- ◆ **Inconsistency across industries and fields.** Industries and fields vary considerably in their propensity to patent inventions; thus, comparing patenting rates among different industries or fields is not advisable (Scherer 1992).
- ◆ **Inconsistency in quality.** The importance of patented inventions can vary considerably, although calculating patent

citation rates (discussed later in this section and in chapter 5) is one method for mitigating this problem.

Despite these and other limitations, patents provide a unique source of information on inventive activities. Patent data provide useful indicators of technical change and serve as a means of measuring inventive output over time.<sup>21</sup> In addition, information on U.S. patenting by foreign inventors enables measurement of the inventiveness in those foreign countries (Pavitt 1985) and can serve as a leading indicator of new technological competition (Faust 1984).<sup>22</sup>

## U.S. Patenting

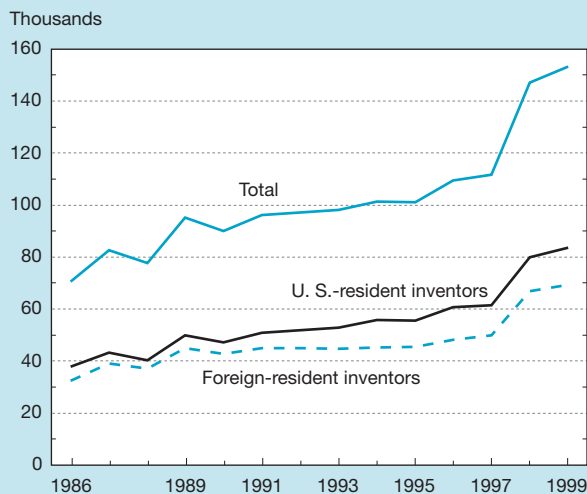
In 1999, more than 153,000 patents were issued in the United States, 4 percent more than that granted a year earlier. This new record number of patents caps off nearly a decade of growth during the 1990s. In 1995, U.S. patents granted fell just short of the previous year's mark, but the upward trend resumed with small increases in U.S. patents granted in 1996 and 1997 before a 32 percent jump in 1998.<sup>23</sup> (See figure 6-22 and appendix table 6-12.)

<sup>21</sup>See Griliches (1990) for a survey of literature related to this point.

<sup>22</sup>It should also be noted that there is concern that patents and other forms of intellectual property may discourage research, its communication, and the diffusion of new technologies. The question arises whether in some respects the extension of intellectual property rights have proceeded too far. To provide answers to guide IPR policy over the next decade and beyond, the Science, Technology and Economic Policy Board (STEP) of the National Research Council (NRC) has undertaken a project to review the purposes of the IPR legal framework and assess how well those purposes are being served. The Board will identify whether there are current or emerging problems of inadequate or over-protection of IPRs that need attention and will commission research on some of these topics.

<sup>23</sup>Although patent applications have been rising, PTO attributes most of the increase in 1998 to greater administrative efficiency and the hiring of additional patent examiners.

Figure 6-22.  
U.S. patents granted: 1986–99



See appendix table 6-12. *Science & Engineering Indicators – 2002*